English name	Scientific Name	HMANA Code	Alpha Code	Protocols 2 and 3
Unidentified Buteo		UB	UNBH*	
Unidentified Eagle		UE	UNEA*	
Unidentified Falcon		UF	UNFA*	
Unidentified Raptor		UR	UNRA*	
Other Raptor		OO		

Table 2. Wind speed codes in Protocol 1

0 – less than 1 km/h (calm, smoke rises vertically)
1 – 1-5 km/h (smoke shift shows drift direction)
2 – 6-11 km/h (leaves rustle, wind felt on face)
3 – 12-19 km/h (leaves, small twigs in constant motion; light flag extended)
4 – 20-28 km/h (raises dust, leaves, loose paper; small branches in motion)
5 – 29-38 km/h
6 – 39-49 km/h (larger branches in motion; whistling heard in wires)
7 – 50-61 km/h (whole trees in motion; resistance felt walking against the wind)
8 – 62-74 km/h (twigs, small branches broken off trees, walking generally impeded)
9 – Greater than 75 km/h

Table 3. Precipitation codes in Protocol 1

0 – none
1 – Haze or fog
2 – Drizzle
3 – Rain
4 – Thunderstorm
5 – Snow
6 – Wind driven dust, sand, or snow

Table 4. Height of flight codes in Protocol 1

Notes: The estimation of height of flight is a function of the location of the monitoring site, in which case an accurate description of the monitoring site is important. For example, a site located in a mountain ridge may likely have birds above of below the horizontal. In this case, this protocol follows the recommendations of HawkWatch International's protocol – hawks below the horizontal will be added a positive or negative sign if above of below the horizontal, respectively. Negative values are naturally only limited to the lower categories of this scale. Height of flight categories apply to vertical height, which should be carefully recorded and not to be confused with side distance.

0 – Below eye level
1 – Eye level to about 30 meters
2 – Birds seen easily with unaided eye (eyeglasses not counted as aids)
3 – At limit of unaided vision
4 – Beyond limit of unaided vision but visible with binoculars – to 10x
5 – At limit of binoculars
6 – Beyond limit of binoculars 10x or less, but can detect with binoculars or telescope of greater power (mark "1" in comment box and note magnification)
7 – No predominant height

HAWK MIGRATION ASSOCIATION OF NORTH AMERICA

STANDARD DATA COLLECTION PROTOCOL FOR RAPTOR MIGRATION MONITORING

1. INTRODUCTION

1.1. Purpose and rationale of a monitoring program. The Hawk Migration Association of North America (HMANA) has promoted the use of a standard data collection protocol for raptor migration monitoring ever since its foundation in 1975. This protocol has been adjusted over time and a data collection form and a brief set of instructions have been made widely available to monitoring sites across North, Middle, and South America.

A monitoring program should provide three types of information: (1) An estimate/sample of population size, (2) An estimate of demographic parameters (e.g. information on population structure provided by data on species' sex and age classes), and (3) A measure of the environmental variables believed to affect the first two estimates (Hutchinson 1978, Ralph et al. 1993).

It is expected that this protocol and its revised contents continue to be clear, simple, and practical for citizen scientists and field biologists collecting data in the field, but also useful and informative for the needs of managers, conservationists, and scientists in later data analysis (Beissinger et al. 2006). This protocol can be easily customized for the particularities of a specific site.

1.2. Objectives of this protocol. The purpose of this document is to describe a standard data collection protocol for raptor migration counts. Although forms and sets of instructions for such protocol already exist, there is very little information on the rationale and background of such instructions (Fuller and Mosher 1987, Kerlinger 1989). This protocol has three specific objectives: (1) Provide standard instructions for raptor migration count data collection across sites, (2) Present the rationale of why these data should be collected and expand specific instructions for data collection procedures, (3) Introduce improvements to basic HMANA protocol that have been in use for many years. This protocol is not intended to replace former, but to stimulate raising the quality of data collection and to facilitate the access and use of information for analysis.

1.3. Organization of this protocol. The current set of HMANA (2006a) standards, termed "Protocol 1" in this document, have been in use since 1976 and revised in 1979 and 1986. This description follows the same format and structure: it starts with a description of the location and coverage where data are collected, the set of target species and population parameters that are recordable under field conditions for that particular site, and instructions for weather and flight recording conditions. This protocol encourages the use of metric system units at all times. Monitoring site specifics, species coverage, and data collection instructions should be carefully documented in a Seasonal Metadata Form (Appendix 2).

2. MONITORING SITE SPECIFICS

2.1. Location. This field includes a description of the localities' specifics, including coordinates in latitude/longitude format, elevation (in meters above the sea level [mASL]), and the choice between a Fixed versus a Mobile monitoring site.

A fixed location is the specific point from where migration counts are done throughout the season. Some sites, however, shift between two or more closely-located sites (e.g. <1-2 km apart) according to wind speed and direction, from where they can observe more migrants.

For monitoring purposes, counting more birds is not the goal but collecting systematic data from one site. No birds (e.g. many zeros) are as informative as many birds recorded. Sites that operate with professional field biologists and volunteers that acknowledge the higher value of data collected from fixed locations should avoid conducting counts from mobile sites. However, since many of these sites are run by citizen scientists whose goals are also recreational, it is very important that those mobile sites clearly label their counts as done from a mobile site and be able to differentiate between the locations used under the same general location name (e.g. Observation Site A, B, or C).

Some monitoring sites along diversion lines run counts from several sites at a time to cover the width of the flight's front. If these localities are fixed and operate in a coordinated fashion, they should be labeled as part of a Survey Line. Other specifics of a Survey Line such as distance between sites, the estimated number of birds that may be double counted (if any), and active communication system in operation should also be documented.

Photographs of the 360 degree view from each site on each year may be of use to document other reasons affecting count records, e.g. new human-made structures or growth of trees that block the field of view, whether counts are done from a tower or from the ground.

2.2. Seasons and dates of operation. A distinction between spring and fall migration season of operation, and the start and end date of field season. The seasonal timing of migrant raptor species have skewed distributions with long, heavy tails (a species comes by in low numbers for a long time, then increases in numbers, reaches a peak, and decreases to low numbers for a long time). Seasonal timing charts of target monitoring species should be used in the choice of seasonal coverage so dates of operation match the largest proportion (e.g. 95% of the migration period or migration window) in as many species as possible. Once dates of coverage have been chosen, the same sampling period should be used annually.

The length of the field season has a strong influence in its power to estimate trends. Lewis and Gould (2000) estimate that counts done over periods of 30 or 60 days have a lower statistical power than counts done over a period of 90 days. The ability of shorter field seasons to estimate population trends decreases because the coefficient of variation of annual counts increases in samples composed of fewer consecutive days of counts. Counts done over periods of >90 days can attain comparable statistical power than counts done over 90 consecutive days.

2.3. Daily times of operation. Start and end times of daily field work should also be planned based on a more detailed knowledge of the diurnal timing of migration at the site. Coastal sites, for example, have a tendency to have an earlier period of migration activity than inland sites (Kerlinger 1989) and appropriate coverage of the 95% window of daily migration should be planned to capture this particularity. The use of standard versus daylight savings times in data sheets and reports should be clearly noted.

Several monitoring sites do not operate on a daily basis. Some of them operate only on weekends and others only do so on days with "favorable" weather when observers believe more migrants can be recorded.

The optimal coverage of a field site is done through daily observations. Therefore the use of counts done over consecutive days is encouraged, since the monitoring usefulness of those data collected over non-consecutive days (e.g. weekend counts), or counts done over a structured sampling calendar (e.g. two days on, one day off), have not been tested.

Observers must clearly document the reason why a count has been interrupted or when a count day was missed, e.g. due to shortage of observers, or low number of birds recorded. The same judgment applies to sites that only operate on days with "unfavorable" weather conditions – the data generated on days with adverse data is as valuable as the one collected in days with good weather.

2.4. General description of the flight. Hawks constrain their migration to routes defined by favorable flight conditions. Site descriptions must select between (1) Diversion Line (a geographic or topographic feature that causes migrants to alter their course so as to avoid crossing the line, making them appear to follow it, e.g. a shoreline followed by hawks avoiding to cross over a large water body); and (2) Leading Line (a geographic or topographic feature that has properties that induce migrants to change their direction of travel so as to follow them, e.g. a mountain ridge with updrafts along its crest) (Mueller and Berger 1967).

3. SPECIES COVERAGE

3.1. Species covered. Each site must clearly define the species focus of their observations. The majority of monitoring sites include mostly raptors, but many of them also record vultures, and other non-raptor diurnal migrants. There are codes for species, sex, and age classes, color morphs, and subspecies in Table 1. Observers should be encouraged to be as accurate as possible with the identification of migrants but to also acknowledge that it is impossible to identify, sex, and age, every single migrant. The percentage of unidentified migrants from multiple sites ranges around 1-2%.

3.2. Migrants and non-migrants. When migrating, raptors commonly remain in stopover areas for several days and move back and forth past the observation point. In some localities, determining whether a species is migrating or not is difficult to discern. Each site must clearly determine what constitutes a migrant (e.g. "a hawk that flies past the observation point and does not come back") and observers must follow clearly written rules to make decisions regarding classifying an individual as a migrant or a "local" hawk.

4. DATA RECORDING AND DATA STORAGE

4.1. Equipment and materials in use. The evolution of optical equipment, field guides, and other field equipment has certainly changed the way migration counts are done in recent years and it has also improved the number of birds correctly detected, identified, and quantified. For this reason, there should be accurate notes on optic equipment in use, data recording equipment and hand instruments (includes instruments in use for collection of weather data and estimations of flight variables such as range-finders and ornithodolite-type equipment [Pennycuick 1982] and electronic weather station information).

Because fatigue influences the quality of data collected, observers should provided a list of personal care equipment and materials at the monitoring site, such as chairs, umbrellas, sunglasses, and other items that reduce fatigue. Other materials that seem of minor importance such as use of an owl decoy, availability of drinking water, and others should also be recorded.

4.2. Weather variables and flight recording conditions. Weather and flight-recording conditions are perhaps the most central variables required for data analysis. Variables recorded at monitoring sites include Wind Speed (Table 2), Precipitation (Table 3), Wind Direction, Cloud Cover, Humidity, Temperature, and Barometric Pressure (see details in Appendix 1 and Tables 2-4). Although Cloud Type recordings are not part of the standard protocol, cloud type may be of help in interpreting conditions of the boundary layer of the atmosphere in the absence of other data such as barometric pressure, humidity, wind, and precipitation.

(A note on cloud type here?/ a small table of cloud types?)

Some sites obtain data from airports and nearby weather stations, but careful records of the location of such sources of information should be noted. Although some variables may no vary greatly at a regional scale (e.g. barometric pressure and humidity) others such as wind speed and direction have a high variation within short distances. Notes on the type of instruments used in these records are important, e.g. humidity and barometric pressure are collected more accurately in weather stations and airports than with hand instruments.

Some localities do the recording of weather variables and flight recording conditions at the beginning of the hour or at half hour. Either choice should be clearly noted as well.

4.3. Identification, detection, and estimation. Sites should describe a scanning technique in use. Scanning should be actively done with naked eye and 8-10x binoculars, telescopes should not be used to find migrants, but only used for identification. Detectability varies in locations along diversion and leading lines and a detailed description of scanning technique per site is important.

Observers must record the identification aids available (books such as Dunne et al. 1988, Wheeler and Clark 2003, Liguori 2005). This version of the protocol for data collection introduces the use of sex and age classes, color morphs, and subspecies information whenever it is possible under field conditions. Although it is acknowledged that it is not possible to determine all the features requested for each record, this information, even if only determined in a low proportion of the records, may be of help in determining population parameters of importance for explaining population trends (e.g. the high proportion of juveniles versus adults in migration counts is an indicator of high recruitment in a given year).

A clear description of estimation methods is also important for locations and species that migrate in flocks using cross-country flights (sensu Pennycuick 1998). The dynamics of these flights involve migrants entering rising thermals from the bottom and gaining altitude as they circle around the center of the thermal to take advantage of the lifting warm air to gain height. Once the top of the thermal is reached, species exit the column in a gliding flight in their desired direction and start the process again when they have lost height.

It is not possible to conduct a good estimation of the number of hawks when they are circling and migrants should be counted when streaming between thermals through the use of hand (clicker) tally counters. Flocking hawks should be directly counted (1, 2, 3, 4…) when possible, or estimated (in groups of 3, 5, 10, 50…). Observers should be aware that the higher the multiple used in these estimates the higher the error estimating the right number of birds. Lower multiples should be chosen whenever possible.

4.4. Personnel and site/personnel coverage, visitors. The number and skill of observers in charge of counts also has a strong influence in the number of migrants recorded. The number of observers that actively participate in the count might be difficult to determine in some stations, since visitors play an active role in spotting birds that the main observer may have not recorded. It is recommended to keep separate track of the counts recorded by "official" and visitor observers. Clear documentation can help to adjust model estimates at the time of data analysis.

Disturbance at the site as a consequence of visitors should also be recorded using the following code: 0=none, 1=low, 2=moderate, and 3=high. These codes are subjective, but may be of help in later data interpretation. Many sites solve the problem of distracting interactions with visitors through the use of brochures and handouts with education and project/organizational outreach materials.

Sites should have a clear "job description" of count coordinator, main field biologist, and field assistant (paid, volunteer, etc.). A simple documentation of the qualifications of the team may be of importance when interpreting data.

Site operation instructions include the division of work at monitoring site and whether there is a clear training scheme for observers. Training is believed to help in reducing inter-observer variation in counts and result in an overall reduction of counts variability across years. Training workshops should include (1) Detailed descriptions of protocol in use, (2) Site-specific procedures, (3) Detection, identification, and estimation of migrants, and (4) Record-keeping and data case/management instructions. Coordination and work calendars should be attached to Seasonal Metadata Form.

4.5. Data collection and management. Data collected in the field should be transferred to a safe location at the end of the work day. Many localities collect field data in field notebooks and data is then transferred to data forms or electronic spreadsheets or databases. If followed appropriately, this procedure reduces the problem of a lost field notebook, since data is already safely stored. Data transfer should be done carefully and proof-read preferably by a different person than the one doing data entry.

Site coordinators must ensure data is safely stored, either in electronic data warehouses such as HawkCount.org (preferred) or in HMANA's paper archive (as a safe backup for electronically-submitted information). HawkCount.org has clear provisions for data use and intellectual proprietary rights and data storage safety procedures (HMANA 2006b).

Some ethical considerations to add in regards to data collection and management are related to the understanding of field crew that in migration counts (1) It is more important to collect data consistently than recording more birds per site, (2) It is better to err on the side of being conservative than inaccurate, (3) Identifications and estimations should also be conservative since a perfect record of identifications of species, sex and age classes, and other data per record is not possible under field conditions.

4.6. Seasonal metadata. Filling a Seasonal Metadata Form at the end of a field season is essential to determine when changes in the data collection protocol have occurred. Information in this form is very important in the later interpretation of data (Appendix 2).

SOURCES OF INFORMATION AND LITERATURE CITED

This protocol was generated from existing data collection protocols of HMANA, Hawk Mountain, HawkWatch International, Illinois Beach State Park, Holiday Beach Migration Observatory, Hawk Ridge, Pronatura Veracruz, Hawk Cliff, and Braddock Bay Bird Observatory. Jeff Smith, Laurie Goodrich, Steve Hoffman, and Sue Ricciardi provided comments on an earlier manuscript. Concepts of leading and diversion lines were obtained from an unpublished manuscript by Keith Bildstein and Chris Farmer.

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